

38. The cooling apparatus according to claim 21 further comprising:
at least one fin on an interior surface of each of said plurality of micro tubes.

No new matter has been added.

REMARKS

Favorable reconsideration of the above-identified application, as previously amended, is respectfully requested. The Office Action of August 14, 2002 contained the following rejections:

1. Claims 1-4, 6, 21-22, 25-26, 29-32, 34 and 36-37 were rejected under 35 U.S.C. 112, first paragraph, because the originally filed specification failed to disclose the elected embodiment of Figure 1 having the claimed first and second seals;
2. Claims 1-4, 6, 8-11 and 21-37 were rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the Applicants regarded as the invention;
3. Claim 5 was rejected under 35 U.S.C. 112, second paragraph, as lacking antecedence.
4. Claims 1-3, 6, 8-11 and 21-37 were rejected under 35 U.S.C. 103 as being unpatentable over **Wright, et al.** (U.S. Patent No. 6,032,726) in view of **Fox, et al.** (U.S. Patent No. 5,285,347);
5. Claim 4 was rejected under 35 U.S.C. 103 as being unpatentable over **Wright** in view of **Fox** and further in view of Applicants' admission of known/conventional prior art.

Each of these will be addressed in turn.

1. Rejection of Claims 1-4, 6, 21-22, 25-26, 29-32, 34 and 36-37 under 35 U.S.C. 112, first paragraph.

Applicants have amended the specification to define the formation of the first and second seals around the micro tube inlet end cap and the micro tube outlet end cap. Support for the claimed first and second seals may be found in FIGURE 1 as originally filed. In Figure 1, the claimed first seal is shown as a horizontal line below the portion of the extrusion 20 marked 28b, which designates the outlet end cap. Similarly, the claimed second seal is shown as a horizontal line above the portion of extrusion 20 marked 28b, which designates the inlet end cap. No new matter has been added.

*no original
disclosure that
seals are
horizontal lines
in Fig. 1*

2. Rejection of Claims 1-4, 6, 8-11 and 21-37 under 35 U.S.C. 112, first paragraph.

Applicants have amended claims 3, 5, 11, 12, and 22-24 to change the phrase "said at least one heat generating component" to "the at least one heat generating component". It is respectfully submitted that this rejection is now moot in view of this amendment. No new matter has been added

*What about
claim 1*

3. Rejection of Claim 5 under 35 U.S.C. 112, first paragraph.

Applicants have amended Claims 5 and 12 to change the phrase "said first exterior extrusion surface" to "said first exterior surface" to establish antecedence with "a first exterior extrusion surface" recited in Claim 1. No new matter has been added.

*NO def.
of (5 & 12) with new*

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4. Rejection of Claims 1-3, 6, 8-11 and 21-37 under 35 U.S.C. 103.

Independent claims 1, 8, and 21 have been amended to include the limitations: “said plurality of micro tubes being formed along an axis relative to said low profile unitary member” and “means for circulating said heat transfer fluid through said inlet end cap, the plurality of micro tubes of said low profile extrusion and said outlet end cap in a manner such that said fluid is injected into said low profile unitary member and ejected from said member parallel to the axis of said micro tubes”

Support for these amendments can be found in Figure 1, and in the specification on pages 7 and 8.

No new matter has been added.

The Examiner submits that the patent of **Wright** discloses all the claimed features of the invention with the exception of fins, a circuit board, a means for circulating the heat transfer fluid and a means for removing heat from the heat transfer fluid. Further, the Examiner considers the height of the device and the claimed channel cross-section to be obvious design choices dependent upon spacial and flow requirements which do not solve any stated problem or produce any new or unexpected result. The Examiner further submits that **Fox** discloses that it is well known in the heat transfer art to have fins on a heat exchanger, a circuit board, a means for circulating the heat transfer fluid and a means for removing heat from the heat transfer fluid for the purpose of cooling a heat generating device with a closed loop heat transfer system. Thus, the examiner rejected claims 1-3, 6, 8-11, and 21-37 as being unpatentable over **Wright** in view of **Fox**. Applicants respectfully disagree for at least three reasons.

First, **Wright** requires several elements that are not necessary in the construction of the present invention. **Wright**, due to the placement of the manifolds perpendicular to the internal cavities, requires that "a wire mesh or other such material can be inserted inside the cavities 11 (and manifolds 14A and 14B) to break up laminar flow boundary layers to create turbulent flow." Col. 4, ll. 41-44. The present invention, however, does not require the use of a wire mesh structure in operation to create turbulent flow. Also, **Wright** requires the assembly to be sealed with "cap plates [that] are *fixed on each end 13 to seal the internal cavities 11.*" Col. 4, ll. 10-11. The cap plates of **Wright** perform no function other than to seal the internal cavities and prevent the leakage of fluid. In contrast, the inlet and outlet end caps of the present invention function both as a seal to contain the fluid contained in the micro tubes, and also to interconnect adjacent and non-adjacent micro tubes and allow the fluid to flow through the extrusion.

Wright further requires other features not necessary in the present invention: "A manifold 14A is *drilled* with a diameter sufficiently large and sufficiently deep into the preform 10 so that *all internal cavities 11 are fluidly connected to the drilled fluid manifold 14A.*" Col. 3, ll. 54-63. Further, "The fluid manifolds 14A and 14B are sized to match standard drill diameters required for the *subsequent tapping of pipe threads* at the entrance to each of the holes forming the manifolds 14A and 14B. Col. 3, ll 66-67; Col. 4, ll. 1-2. As discussed above, the present invention does not need or require a separately drilled and tapped manifold as in **Wright**. The end caps utilized in the present invention serve **both** as seals **and** manifolds, thus eliminating the need for separately drilled and tapped manifold holes as in **Wright**.

The above mentioned differences are a distinct advantage providing several benefits in the use of dual purpose end caps. First, the production costs of the present invention are decreased because separate steps for drilling , tapping, and sealing are *not* required in the manufacturing process of the present invention. As discussed above, **Wright** requires a separate sealing process step to seal the heat transfer fluid in the micro tubes, as well as separate drilling and tapping steps to interconnect the micro tubes in fluid communication. Col. 4, ll. 10-11; Col. 3, ll. 54-63; Col. 3, ll 66-67; Col. 4, ll. 1-2.

Another advantage of the present invention is a significantly decreased likelihood of component damage caused by error in the inlet and outlet hole formation leading to leakage of the heat transfer fluid. In **Wright**, “The manifold 14A is drilled with a diameter *sufficiently large and sufficiently deep* into the preform 10 so that all internal cavities 11 are fluidly connected to the drilled fluid manifold 14A.” Col. 3, ll. 58-63. Also, as shown in Figure 1, **Wright** has at least two levels of micro tubes, stacked one on the other. These features make the manufacturing tolerances more precise than the present invention because the manifold must be positioned in such a manner so as to ensure that there is an adequate connection to and drainage of the micro tubes, and that the outer heat transfer surfaces are not structurally compromised. **Wright** states “ The described embodiment is also very well suited to withstand the applied clamping pressures which hold the various elements of the thermoelectric heat exchanger together[.]” Col. 3, ll. 45-48. However, slight misalignment of the drill bit might weaken the outer walls of the heat transfer surfaces and cause cracking and fluid leakage during subsequent clamping of the extrusion to a heat generating component.

Still another advantage of the present invention is in the efficiency of heat transfer between the heat generating component and the low profile extrusion. This amendment distinguishes the present invention in that **Wright** requires the heat transfer fluid to be injected perpendicular to the fluid channels. Col. 3, ll. 57-58. As stated above, **Wright** requires a wire mesh structure to be added into the low profile extrusion to ensure efficient heat transfer. Col. 4, ll. 41-44. The present invention allows for efficient heat transfer without the need for any additional structures within the micro tubes due to the flow of the transfer fluid into the device in axial alignment with the micro tubes.

Second, **Wright** requires an added process step in the manufacture of the heat sink. Specifically, the end plates utilized in **Wright** need to be welded to the preform in order to provide an adequate seal. Col. 4, ll. 10-18. Further processing is required, because "upon cooling, the weld tends to *warp the preform*, and this requires additional process steps to ensure flatness of the preform surfaces." Col. 4, ll. 16-18. In an alternate approaches, "brazing is more expensive and more prone, compared to welding, to leave undesirable voids in the ceiling surface for leaks." Col. 4, ll. 21-25. Moreover, "Soldering has the same disadvantages as brazing." Col. 4, ll. 25-26. By welding the end plates to the preform, **Wright** requires that "both of the surfaces 21 and 22 are *ground flat* as needed before the assembled heat transfer plate is mounted to the heat generating components. Alternately, the surfaces 21 and 22 may be *machined or lapped*." Col. 4, ll. 33-38. The present invention, however, does not require the subsequent lapping and machining of the extrusion surface in order to have a flat surface on which to make thermal contact with a heat generating device. Thus, the present invention can perform the stated function of **Wright**, which is cooling heat generating components,

but *without* the wire mesh, *without* the cap plate seals, *without* the drilled manifold, and *without* the subsequent machining steps of grinding, lapping, and machining. The present invention has thus distinctly simplified that of **Wright**, *without* a corresponding loss of capability.

Third, the present invention has characteristics that are superior to those in **Wright**. In the machining processes of **Wright**, where metal is ground flat and holes are drilled, tiny particles of metal flakes are left behind. These tiny particles of metal may become problematic when introduced in a system having sensitive electronic devices. As stated above, **Wright** requires the step of machining one surface of the preform to obtain an even surface (See Col. 4, ll. 16-18). An even, smooth surface is required to maximize heat transfer between the preform and the heat generating device and to prevent damage to sensitive electronic devices. The present invention is manufactured in such a way that there is no need to flatten the surface of the extrusion in contact with the heat generating element. Moreover, the present invention does not require holes to be drilled into the extrusion, but instead incorporates the manifold holes of Wright into the inlet and outlet end caps. It is critical, in the confined spaces common in notebook type computers where the present invention is particularly well suited to function, that *no extraneous metal particles are present in the system*. These metal particles produced by the machining and drilling processes in **Wright** could short-circuit and destroy sensitive electronic components. To minimize this hazard, **Wright** would further require the added steps of polishing *and* washing to remove as many extraneous metal particles as possible.

Fox alone does not cure the problems of **Wright**. **Fox** teaches a hybrid heat sink of a non-unitary construction, which is a feature of the present invention. Col. 5, ll. 49-51. Further, **Fox**

present.
not claimed by Fox relied upon for disclosure of connecting microtubes.
teaches away from adjacent and non-adjacent fluid communication between microtubes, which is also a feature of the present invention. Col. 5, ll. 43-45. The combination of **Fox** and **Wright** still lacks the claimed end caps, which function as both to seal the extrusion and to connect the micro tubes in fluid communication. **Wright**, as discussed above, requires "cap plates that are fixed on each end 13 to seal the internal cavities 11." Col. 4, ll. 10-11. As also discussed above, **Wright** requires that "the manifold 14A is drilled with a diameter sufficiently large and sufficiently deep into the preform so that internal cavities 11 are fluidly connected to the drilled fluid manifold 14A." Col. 3, ll. 54-63.

present
Wright, therefore, teaches away from using end caps which serve a dual function.

not relied upon for teaching end caps.
Fox, moreover, teaches away from using a single end cap, and uses flexible tubing "attached to the fittings, thereby allowing a path for the fluid to flow through the hybrid heat sink[.]" Col. 5, ll. 62-64. It is readily apparent that the combination of **Fox** and **Wright** yields a structure that does

not meet the present invention as claimed in at least claims 1, 8, and 21, which include the following non obvious elements: 1) unitary construction, 2) fluid communication between adjacent and non-adjacent micro tubes, 3) efficient heat transfer without the need for additional structures within the micro tubes due to the flow of the transfer fluid into the device in axial alignment with the micro tubes, and 4) an outlet and inlet end cap that functions both to seal the extrusion and to provide the fluid communication between adjacent and non-adjacent micro tubes. **Fox** discloses a heat exchanger, a circuit board, a means for circulating the heat transfer fluid and a means for removing heat from the heat transfer fluid for the purpose of cooling a heat generating device with a closed loop transfer system. **Wright** discloses an extruded internal cavity heat sink, but requires the added features of drilled manifold holes and cap plates welded to seal the internal cavities. The present invention has

the advantage of using dual purpose inlet and outlet end caps, and does not require separate manifold holes to be drilled, or a separate cap plate to welded to the extrusion.

Thus, the claimed invention represents a patentable improvement over the prior art which, in addition to the above discussed structural differences, provides several advantages. First, the present invention allows the micro tubes to be interconnected at both ends, using two end caps, thus making the device more reliable. Second, the present invention requires one less step in the manufacturing process, thus making the device cheaper. Third, the present invention is less likely to damage sensitive electronic components because the manufacturing process does not require machining and lapping.

Accordingly, it is respectfully submitted in view of the above amendments that the independent claims in the present application are in condition for allowance, and all other dependent claims are submitted to be allowed as they include the limitations of the independent claims from which they depend.

5. Rejection of Claim 4 under 35 U.S.C. 103

In view of the above grounds for allowability of independent claims 1, 8 and 21, it is submitted that dependent claim 4 is now allowable for the same reasons. However, and for expediency, it is unclear whether examiner has considered the materials relating to thermal interface material Applicants submitted in response to the office action dated March 22, 2002. These were materials establishing that it is well understood in this art that “thermal interface material” refers to such substances as W.L. Gore and Associates, Inc.’s POLARCHIP™ (flouropolymer composites that

consist of an ePTFE matrix filled with Boron Nitride particles), Thermalloy, Inc.'s Thermalcote II (Non-Silicone Thermal Joint Compound), Stockwell Rubber Company's thermal management components (low durometer Silicone or compressible sponge), and thermal greases in general. Applicant provided Applicants' attorney with the specimens attached to the response to the office action dated March 22, 2002 as Exhibit A, comprising advertising for such materials. Such products and thermal greases in general are well known to a man of the art to be "conventional thermal interface material."

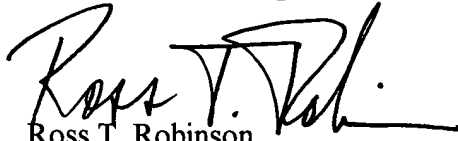
Accordingly, in view of the above arguments, claim 4 is respectfully submitted to be in condition for allowance.

It is believed that entry of this Amendment is warranted under the provisions of 37 C.F.R. § 1.116 as it clearly causes the claims active in this application to be allowable over the art of record. Accordingly, it is believed that entry of this Amendment is warranted under the provisions of 37 C.F.R. § 1.116.

In view of the foregoing, Applicants respectfully requests the thorough reconsideration of this application and earnestly solicits an early notice of allowance.

Respectfully submitted,

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EXHIBIT A

Revised Specification paragraph after response filed to August 14, 2002 office action:

“The extrusion 20 is sealed by a first seal at an inlet end cap 28a and a second seal at an outlet end cap 28b. The micro tube inlets 21a of the micro tubes 21 in the extrusion 20 are interconnected in fluid communication, and to the inlet tube 18, by [an] the inlet end cap 28a. Similarly, the micro tube outlets 21b of the micro tubes 21 in the extrusion 20 are interconnected in fluid communication, and to the outlet tube 22, by [an] the outlet end cap 28b. Alternatively, micro tube outlets 21a and/or 21b may be sealed by crimping the low profile member 20. Micro tubes outlets 21a and/or 21b may be individually sealed or connected in fluid communication. The heat exchanger 16 may contain a fluid reservoir (not shown) therein for housing a fluid such as water, glycol, alcohol, or other conventional refrigerants. Referring now to Fig 1d, a wick, such as screen 21e may be provided within one or all of micro tubes 21. In this case, fluid from the heat exchanger 16 is circulated through the inlet tube 18, the low profile extrusion 20, the outlet tube 22, and the tubing 26 via the pump 24. Alternatively, the entire cooling apparatus 10 may be evacuated and charged with fluid which is then circulated via the pump 24.”

EXHIBIT B

Pending claims after response filed to August 14, 2002 office action:

Sub 118 1. (Fourth amendment) A cooling apparatus for removing heat from at least one heat generating component, said cooling apparatus comprising:

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a low profile metal unitary member comprised of one piece of metal, said low profile unitary member having a first exterior surface adapted for receiving heat from the at least one heat generating component and having a plurality of micro tubes formed of said one piece of metal having a flattened heat transfer surface, said low profile metal unitary member having a micro tube inlet comprised of said one piece of metal and a micro tube outlet comprised of said one piece of metal, said low profile metal unitary member providing an entirely metallic thermal path for conducting heat from said first exterior surface to a heat transfer fluid contained within said plurality of micro tubes, said plurality of micro tubes being formed along an axis relative to said low profile unitary member;

an inlet tube;

an inlet end cap interconnecting the micro tube inlets in fluid communication and connecting the micro tube inlets in fluid communication with said inlet tube;

an outlet tube;

an outlet end cap interconnecting the micro tube outlets in fluid communication and connecting the micro tube outlet in fluid communication with said outlet tube;

said low profile metal unitary member being sealed by a first seal and a second seal for enclosing said low profile metal unitary member, said first seal being formed at said inlet end

cap, said second seal being formed at said outlet end cap, said first seal forming a first seal length and said second seal forming a second seal length;

each of said plurality of microtubes being fluidly connected to adjacent and non-adjacent microtubes via said inlet end cap and said outlet end cap;

means for circulating said heat transfer fluid through said inlet tube, said inlet end cap, the plurality of micro tubes of said low profile metal unitary member, said outlet end cap, and said outlet tube in a manner such that said fluid is injected into and ejected from said low profile unitary member parallel to said axis of said micro tubes ; and

means for removing heat from said heat transfer fluid.

2. (Twice Amended) The cooling apparatus of claim 1, wherein said first seal and said second seal are formed by welding.

3. (Twice amended) The cooling apparatus of claim 2, wherein said member is in thermal contact with the at least one heat generating component, and said member is further in direct contact with said heat transfer fluid.

4. (Amended) The cooling apparatus of claim 2, wherein said low profile metal member is plated on an exterior surface with a metal material.

5. (Amended) The cooling apparatus of claim 1, further comprising at least one

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thermoelectric cooling unit disposed between the at least one heat generating component and said first exterior surface.

6. (Amended) The cooling apparatus of claim 1, wherein said low profile metal member further comprises a plurality of fins on a second exterior surface opposite said first exterior surface adapted for receiving heat.

7. (Amended) The cooling apparatus of claim 1, wherein said low profile metal member further comprises a plurality of fins or grooves on an interior surface of each of said plurality of micro tubes.

8. (Amended) A cooling apparatus for removing heat from at least one heat generating component, said cooling apparatus comprising:

a low profile unitary member having a flattened exterior extrusion surface adapted for receiving heat from the at least one heat generating component and a plurality of micro tubes with a micro tube inlet and a micro tube outlet, said plurality of micro tubes being formed along an axis relative to said low profile unitary member;

at least one fin on an interior surface of at least one of said plurality of micro tubes;

means for circulating a heat transfer fluid through said plurality of micro tubes of said low profile member in a manner such that said fluid is injected into said low profile unitary member and ejected from said member parallel to the axis of said micro tubes; and

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means for removing heat from said heat transfer fluid.

9. The cooling apparatus of claim 8, wherein each of said micro tubes are substantially rectangular in shape.

65 10. (Amended) The cooling apparatus of claim 8, wherein said low profile member is formed of a metal material.

11. (Amended) The cooling apparatus of claim 10, wherein said metal material is in thermal contact with the at least one heat generating component, and said metal material is further in direct contact with said heat transfer fluid.

12. (Amended) The cooling apparatus of claim 8, further comprising at least one thermoelectric cooling unit disposed between the at least one heat generating component and said first exterior extrusion surface.

13. (Amended) The cooling apparatus of claim 8, wherein said low profile extrusion further comprises at least one fin on an interior surface of each of said plurality of micro tubes.

21. (Thrice Amended) A cooling apparatus for removing heat from at least one heat generating component, said cooling apparatus comprising:

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a low profile metal unitary member comprised of one piece of metal having a first exterior extrusion surface adapted for receiving heat from the at least one heat generating component and a plurality of micro tubes with a micro tube inlet comprised of said one piece of metal and a micro tube outlet comprised of said one piece of metal, said plurality of micro tubes being formed along an axis relative to said low profile unitary member, said low profile metal unitary member providing an entirely metallic thermal path for conducting heat from said first exterior extrusion surface to a heat transfer fluid contained within said plurality of micro tubes, said member having a profile of less than approximately 0.1 inches;

an inlet end cap interconnecting the micro tube inlets in fluid communication;

an outlet end cap interconnecting the micro tube outlets in fluid communication;

said low profile metal unitary member being sealed by a first seal and a second seal for enclosing said low profile metal unitary member, said first seal being formed at said inlet end cap, said second seal being formed at said outlet end cap, said first seal forming a first seal length and said second seal forming a second seal length;

each of said plurality of micro tubes being fluidly connected to adjacent and non-adjacent micro tubes via said inlet end cap and said outlet end cap;

means for circulating said heat transfer fluid through said inlet end cap, the plurality of micro tubes of said low profile extrusion and said outlet end cap in a manner such that said fluid is injected into said low profile unitary member and ejected from said member parallel to the axis of said micro tubes; and

means for removing heat from said heat transfer fluid.

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22. (Amended) The cooling apparatus according to claim 21 wherein:
said cooling apparatus is affixed to a printed circuit board for cooling the heat generating component.
23. (Amended) The cooling apparatus according to claim 1 wherein:
said cooling apparatus is affixed to a printed circuit board for cooling the heat generating component.
24. (Amended) The cooling apparatus according to claim 8 wherein:
said cooling apparatus is affixed to a printed circuit board for cooling the heat generating component.
25. The cooling apparatus according to claim 1, wherein each of said micro tubes are polygonal in cross section.
26. The cooling apparatus according to claim 1, wherein each of said micro tubes are substantially square in cross section.
27. The cooling apparatus according to claim 8, wherein said micro tubes are polygonal in cross section.

~~28. The cooling apparatus according to claim 8, wherein said micro tubes are substantially square in cross section.~~

~~29. The cooling apparatus according to claim 21, wherein said micro tubes are polygonal in cross section.~~

~~30. The cooling apparatus according to claim 1, wherein said micro tubes are substantially square in cross section.~~

~~31. The cooling apparatus according to claim 21, wherein said micro tubes are substantially square in cross section.~~

~~32. The cooling apparatus according to claim 1 wherein:
said member has a profile of approximately 0.1 inches.~~

~~33. The cooling apparatus according to claim 8 wherein:
said member has a profile of approximately 0.05 inches.~~

~~34. The cooling apparatus according to claim 1, wherein said micro tubes have a diameter of between approximately .0625 inches and 0.5 inches.~~

35. The cooling apparatus according to claim 8, wherein said micro tubes have a diameter of between approximately .0625 inches and 0.5 inches.

36. The cooling apparatus according to claim 21, wherein said micro tubes have a diameter of between approximately .0625 inches and 0.5 inches.

37. The cooling apparatus according to claim 21, wherein said low profile is approximately 0.05 inches.

38. The cooling apparatus according to claim 21 further comprising:
at least one fin on an interior surface of each of said plurality of micro tubes.